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LOCATION PREDICTION USING WIRELESS SIGNALS ON ONLINE SOCIAL NETWORKS

TECHNICAL FIELD

This disclosure generally relates to online social networks, places, and geo-location.

BACKGROUND

A social-networking system, which may include a social-networking website, may enable its users (such as persons or organizations) to interact with it and with each other through it. The social-networking system may, with input from a user, create and store in the social-networking system a user profile associated with the user. The user profile may include demographic information, communication-channel information, and information on personal interests of the user. The social-networking system may also, with input from a user, create and store a record of relationships of the user with other users of the social-networking system, as well as provide services (e.g., wall posts, photo-sharing, event organization, messaging, games, or advertisements) to facilitate social interaction between or among users.

The social-networking system may send over one or more networks content or messages related to its services to a mobile or other computing device of a user. A user may also install software applications on a mobile or other computing device of the user for accessing a user profile of the user and other data within the social-networking system. The social-networking system may generate a personalized set of content objects to display to a user, such as a newsfeed of aggregated stories of other users connected to the user.

A mobile computing device—such as a smartphone, tablet computer, or laptop computer—may include functionality for determining its location, direction, or orientation, such as a GPS receiver, compass, gyroscope, or accelerometer. Such a device may also include functionality for wireless communication, such as BLUETOOTH communication, near-field communication (NFC), or infrared (IR) communication or communication with a wireless local area networks (WLANs) or cellular-telephone network. Such a device may also include one or more cameras, scanners, touchscreens, microphones, or speakers. Mobile computing devices may also execute software applications, such as games, web browsers, or social-networking applications. With social-networking applications, users may connect, communicate, and share information with other users in their social networks.

SUMMARY OF PARTICULAR EMBODIMENTS

In particular embodiments, the social-networking system **1160** may predict a second geographic location that a user will visit subsequent to the user's presence at a first geographic location. In other words, the social-networking system **1160** may predict the next place the user will visit given information about a previous place the user has visited or will visit. In particular embodiments, a technical problem arising in the field of geo-location may be providing users with information associated with a geographic location they will visit in the future based on a current geolocation. The technical solutions described herein of automatically predicting a second geographic location that a user will visit subsequent to the user's presence at a first geographic location and sending the user information associated with the second geographic location may improve computing

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processes related to receiving and executing queries by reducing the need for the user to send queries related to the second geographic location, which may reduce the computing resources needed for such processes. In particular embodiments, the social-networking system **1160** may calculate the probability $P(k|X)$ that a user will visit a second geographic location k subsequent to the user's presence at given a first geographic location X . The social-networking system **1160** may use a model trained by machine learning, which may take an input embedding representing a first place-entity corresponding to a first geographic location and output a predicted second place-entity corresponding to a second geographic location that the user will subsequently visit. In particular embodiments, the prediction may be a most probable second geographic location that the user will subsequently visit, a confidence score representing the confidence that the user will subsequently visit a particular second geographic location, or it may be a ranked list of probable second geographic locations that the user will subsequently visit. In particular embodiments, features of a place-entity may be selected by feature extraction to generate an embedding representing a place-entity. The features extracted may include the category of the place-entity (e.g., bar, gym), the time of the user's visit to the geographic location corresponding to the place-entity (e.g., time of day, day of week), the hours that the geographic location corresponding to the place-entity is open, popular hours of a geographic location corresponding to the place-entity, or any other suitable features related to the place-entity. User attributes may also be used to generate an embedding (e.g., an embedding of a place-entity may be reconstructed from embeddings of the users visiting the geographic location corresponding to the place-entity). In particular embodiments, training data used to train a machine-learning model may be from users of an online social network or any other suitable data. To train a machine-learning model, positive and negative pairs of first geographic locations and second geographic locations may be used. In particular embodiments, a machine-learning model used to generate place-entity embeddings may be evaluated. As an example and not by way of limitation, for an evaluation set, the mean-reciprocal rank (MRR) may be used to evaluate the machine-learning model. In particular embodiments, a machine-learning model may be used to make a prediction about which second geographic location a user will visit to subsequent to a given current first geographic location of the user. In particular embodiments, a prediction may be used to suggest a second geographic location a user should visit next. In particular embodiments, a prediction may be used to deliver content associated with the predicted second geographic location to the client system **1130** of the user. In particular embodiments, a prediction may be used to predict a user's current second geographic location based on a first geographic location previously visited by the user. As an example and not by way of limitation, a user's current location may be unknown or unable to be precisely determined. The social-networking system **1160** may use a previous first geographic location visited by the user to predict a user's current second geographic location. In particular embodiments, the prediction may be used as one of many factors in predicting the user's current geographic location. As an example and not by way of limitation, the predicted current second geographic location may be based on the output of a machine-learning model as well as GPS data, wireless signal-information received by the client system **1130** of the user, or any other suitable information. Although this disclosure describes predicting a second geographic